IJSPT

ORIGINAL RESEARCH

CORRECTED ERROR VIDEO VERSUS A PHYSICAL THERAPIST INSTRUCTED HOME EXERCISE PROGRAM: ACCURACY OF PERFORMING THERAPEUTIC SHOULDER EXERCISES

David J Berkoff, MD[1,2]
Kamesh Krishnamurthy[3]
Jennifer Hopp, MD[5]
Laura Stanley, DPT[2]
Ken Spores, DPT[8]
David Braunreiter, MD[6,7]

ABSTRACT

Background and Purpose: The accurate performance of physical therapy exercises can be difficult. In this evolving healthcare climate it is important to continually look for better methods to educate patients. The use of handouts, in-person demonstration, and video instruction are all potential avenues used to teach proper exercise form. The purpose of this study was to examine if a corrected error video (CEV) would be as effective as a single visit with a physical therapist (PT) to teach healthy subjects how to properly perform four different shoulder rehabilitation exercises.

Study Design: This was a prospective, single-blinded interventional trial.

Methods: Fifty-eight subjects with no shoulder complaints were recruited from two institutions and randomized into one of two groups: the CEV group (30 subjects) was given a CEV comprised of four shoulder exercises, while the physical therapy group (28 subjects) had one session with a PT as well as a handout of how to complete the exercises. Each subject practiced the exercises for one week and was then videotaped performing them during a return visit. Videos were scored with the shoulder exam assessment tool (SEAT) created by the authors.

Results: There was no difference between the groups on total SEAT score (13.66 $\pm$ 0.29 vs 13.46 $\pm$ 0.30 for CEV vs PT, p = 0.64, 95% CI [-0.06, 0.037]). Average scores for individual exercises also showed no significant difference.

Conclusion/Clinical Relevance: These results demonstrate that the inexpensive and accessible CEV is as beneficial as direct instruction in teaching subjects to properly perform shoulder rehabilitation exercises.

Level of Evidence: 1b

Keywords: Exercises, shoulder, physical therapy, video

[1] Department of Orthopedics and Emergency Medicine, University of North Carolina Chapel Hill, Chapel Hill, NC, USA
[2] Department of Exercise Sport Science UNC Chapel Hill,Chapel Hill, NC USA
[3] Department of Neurobiology, Duke University, Durham, North Carolina, USA;
[4] Duke University Medical Scientist Training Program, Durham, North Carolina, USA
[5] HCA Virginia Sports Medicine, Midlothian VA
[6] Assistant Professor of Family Medicine in Clinical Medicine, Weill Cornell Medical College
[7] Assistant Professor of Clinical Family Medicine, Houston Methodist Institute for Academic Medicine Houston Methodist Orthopedics and Sports Medicine, Sugar Land TX
[8] Proaxis Physical Therapy, Carrboro, NC, USA (for Ken Sports DPT)

CORRESPONDING AUTHOR
David J Berkoff, MD
UNC Orthopaedics
3142 Bioinformatics Building CB 7055
Chapel Hill, NC 27599
E-mail: David_berkoff@med.unc.edu

INTRODUCTION

Developing effective methods to communicate patient instructions can prove beneficial in ensuring adherence and optimal outcomes to prescribed therapies.[1] The field of physical therapy relies heavily on patients regularly and accurately performing home exercise routines.[2,3] For these routines to be successful, information about proper exercises, techniques, and frequency must be reliably relayed from provider to patient. Given that medical literacy is a critical determinant of health care outcomes,[4,5,6] identifying reliable ways to impart educational concepts to patients remains an important goal.

The earliest research on substitutes for direct teaching utilized brochures that displayed, either in verbal or pictorial format, exercise instructions and schedules.[7,8] In both of these studies, subjects receiving direct therapist instructions performed better than those who were taught by a brochure, suggesting that more effective methods of communication are needed to substitute for direct one-on-one interaction. Subsequent research has focused on the use of video recordings for patient instruction. The authors found that using videotape was at least as effective as direct teaching,[9] if not more effective,[10,11] in instructing subjects to accurately perform exercises.

All of the above examples used videos that demonstrated the "correct" method of performing an exercise. However, it is well established that knowing the incorrect method of performing a task, or how an incorrectly performed task can be rectified, can improve learning.[12,13,14,15] Given this, developing a video demonstration that not only displayed the correct method of performing an exercise, but also common incorrect methods, may prove as effective as in-person teaching in communicating information to subjects. Such video demonstrations are termed corrected error videos (CEV). Reo and Mercer examined whether CEV could be used to teach upper-extremity exercises.[11] They tested subjects in one of four instruction methods: live instruction, CEV, error-free video, and handout. They found that, 24hrs following instruction, no difference in performance (rated using a checklist of critical criteria for each exercise) was found between subjects taught using CEV, error-free video, or live instruction.[11] These results suggest that, at least in the short-term and for a particular video, CEV is as effective as live instruction. However, to date, longer-term retention of instruction has not been explored.

The purpose of this study was to examine if a corrected error video (CEV) would be as effective as a single visit with a physical therapist (PT) to teach healthy subjects how to properly perform four different shoulder rehabilitation exercises. The hypothesis was that the CEV would be as effective as direct instruction in teaching healthy subjects four shoulder rehabilitation exercises—scapular retraction, external rotation with elastic resistance, internal rotation with elastic resistance, and the standing row with elastic resistance.

METHODS

Subjects were recruited at two independent institutions, the University of North Carolina (UNC) and Houston Methodist (HM). Inclusion criteria included no prior history of shoulder pathology, fluency in English, and daily access to and proficiency in using a DVD player. Exclusion criteria included dementia or cognitive disability, vision or hearing impairments, or pregnancy. Subjects with a self-reported history of receiving formal physical therapy training in the past year or experience with study exercises were also excluded. At both institutions, randomization was done using standard block randomization in blocks of four.

At UNC, 30 subjects ranged from 18 to 25 years of age (average age = 21.2, SD =3.7; 11 male and 19 female). Subjects were recruited from the student body and campus. Sixteen were randomized into the CEV group and 14 into the physical therapy (PT) group. Two subjects, both in the PT visit group, were excluded from analysis because one subject did not return for follow-up evaluation and one had pain while performing the exercises and chose not to return. In addition, two subjects in the CEV group were excluded from the analysis: these subjects were inadvertently not informed which exercises on the disc to complete (the DVD contained more than just the four shoulder exercises used in the study). It should be noted that their exclusion did not alter the statistical significance of any of the results. At the completion of the study, there were 14 CEV subjects and 12 PT subjects from this institution.

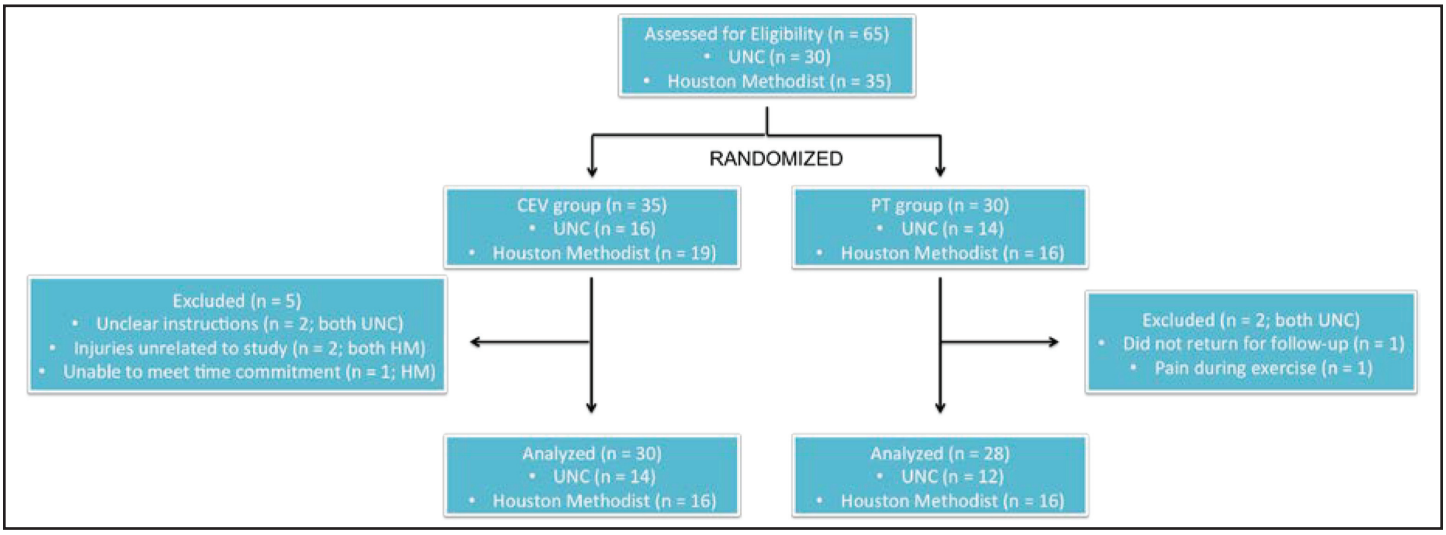

Figure 1. *Flow diagram summarizing subject participation.*

At HM, 35 subjects were recruited into the study. Subjects from this site were recruited from the hospital staff. Nineteen subjects were randomized into the CEV group, while 16 were included in the PT group. Three subjects, all in the CEV group, were removed from the study: two subjects suffered unrelated injuries and were not able to complete the study, and a third could not meet the time commitment. Ultimately, 32 subjects ranging from 28 to 66 years of age (average age 42.2, SD =11.3; 7 male and 25 female) were randomized with 16 in the CEV group and 16 in the PT group. A consort diagram diagraming the outcomes of subjects (n = 58) recruited is shown in Figure 1.

CEV subjects were given the DVD and a single instruction page highlighting which exercises to perform. For the PT group, a physical therapist gave subjects thirty minutes of in-person instructions and a handout outlining the exercises taught during the session. Both groups were then asked to return after one week of home practice. Four exercises were tested: scapular retraction, standing rows with elastic resistance, external rotation, and internal rotation with elastic resistance. All subjects were asked to record the number of days they practiced the exercises, and were required to perform at least three days of home practice. In addition, subjects at UNC were asked to score their resource's "Ease of Use" and "Ease of Understanding" on a scale of one to 10 (with 10 being the best score), developed by the authors. Subjects at HM were not asked these questions as part of the study.

On the day of testing, subjects were video recorded from the front and side while they performed ten repetitions of each exercise without coaching. Blinded physical therapists then used the Shoulder Exercise Assessment Test (SEAT), a shoulder scoring criteria developed by an unaffiliated physical therapist and the author (DJB) to independently score subject performance on each exercise while blinded to group; this scale has yet to be validated for reproducibility between scorers (see Discussion). The criterion for SEAT scoring is displayed in Figure 2, with a higher score denoting more accurate performance. Scoring for each exercise was based on performance on the majority of the repetitions (i.e. correct performance in >6 repetitions was scored as accurate performance). Each subject was scored by two independent physical therapists at UNC and three independent physical therapists at HM. The average score for each subject (from two PTs at UNC and three at HM) was used in all statistical analyses. All statistical analyses were conducted using non-parametric statistical analysis (with significance at $p < 0.05$) using Prism 5 Statistical tests used are noted in the text.

RESULTS

Table 1 presents all outcomes for the total subject pool. All outcomes are reported as mean +/- standard error.

Assigned Score Given Listed Criteria	Score A: Scapular Retraction	Score B: External Rotation with Elastic Resistance	Score C: Internal Rotation with Elastic Resistance	Score D: Standing Row with Elastic Resistance
1	The subject's elbow and shoulder move the same distance.	The subject placed a towel roll between his/her elbow and side	The subject placed a towel roll between his/her elbow and side	The subject pulled back on band simultaneously with both arms
2	The subject retracted his/her scapula	The subject externally rotates his/her shoulder	The subject placed a towel roll between his/her elbow and side	The subject stopped motion at 0 degrees of shoulder extension
3	The subject maintained neutral trunk alignment in all planes	The subject externally rotates his/her shoulder	The subject maintained 90 degrees of elbow flexion	The subject retracted his/her shoulder blades
4	The subject maintained neutral neck alignment in all planes	The subject maintained neutral trunk alignment in all planes	The subject maintains neutral scapular position	The subject controlled eccentric arm and shoulder movement
5	The subject depressed his/her should girdle	N/A	N/A	N/A

Figure 2. *Description of the Shoulder Exercise Assessment Test Scoring system*

Subjects in the CEV group at UNC reported a strong trend towards increased Ease of Understanding for their material, although the result was not statistically significantly different than the PT group (9.31 $\pm$ 0.24 vs. 8.08 $\pm$ 0.57; p = 0.06, Mann-Whitney U test; 95% CI [-2.39, -0.07]). Subjects in the CEV group at UNC also reported a strong trend towards increased ease of use, though the result did not reach significance (9.44 $\pm$ 0.20 vs. 8.67 $\pm$ 0.40; p = 0.09, Mann-Whitney U test; 95% CI [-1.62, 0.08]). As noted in the Methods, subjects at HM were not asked about ease of use or understanding. Combining subjects from UNC and HM, there was no difference in the number of times in a week subjects in each group practiced their exercises (3.94 $\pm$ 0.34 vs. 3.83 $\pm$ 0.21 for CEV vs. PT visit).

Comparing the CEV and PT groups across the two institutions, the SEAT scores for each exercise was not significantly different from one another except for the standing row (Kruskal-Wallis test with post-hoc Dunn's test) (Figure 3). The subjects at HM received lower scores independent of participating in the CEV or PT group.

Combining the data from both institutions, no significant differences were found between the CEV and PT visit group for any of the four exercises: scapular retraction (3.87 $\pm$ 0.11 vs. 3.86 $\pm$ 0.12), standing row (2.99 $\pm$ 0.11 vs. 2.95 $\pm$ 0.13), external row (3.34 $\pm$ 0.12 vs. 3.24 $\pm$ 0.11), and internal row (3.49 $\pm$ 0.13 vs. 3.43 $\pm$ 0.12). These results are shown in Figure 4. Finally, a total SEAT score was calculated for each subject by adding the score for each individual exercise and dividing by the number of criteria scored. No significant difference was found between the CEV and PT visit group for the total score (0.80 $\pm$ 0.02 vs. 0.79 $\pm$ 0.02, (Figure 4).

DISCUSSION

Given the importance of effectively communicating patient instruction during physical therapy visits

Table 1. *Descriptive outcomes for CEV and PT groups and PT group for all subjects (n = 58)*

	CEV Group (n=30, unless otherwise noted)	PT Group (n=28, unless otherwise noted)
Ease of Understanding	9.31 ± 0.24 (n = 14, UNC only)	8.08 ± 0.57 (n = 12, UNC only)
Ease of Use	9.44 ± 0.20 (n = 14, UNC only)	8.67 ± 0.40 (n = 12, UNC only)
Times Practiced per week	3.94 ± 0.34	3.83 ± 0.21
Scapular Retraction (SEAT A score)	3.87 ± 0.11	3.857 ± 0.12
External Rotation with Elastic Resistance (SEAT B score)	3.34 ± 0.12	3.24 ± 0.11
Internal Rotation with Elastic Resistance (SEAT C score)	3.49 ± 0.13	3.43 ± 0.12
Standing Row with Elastic Resistance (SEAT D score)	2.99 ± 0.11*	2.95 ± 0.132*
Total SEAT Score	0.804 ± 0.017	0.79 ± 0.018

*= statistically significant difference between groups at p<0.05

with increasingly limited patient-provider interaction time, the hypothesis of this study was that using a DVD instruction in general, and CEV instruction in particular, would be as effective as direct clinical instruction in delivering the critical information necessary for patients to accurately perform home shoulder exercises. To this end, this study was designed to examine if a corrected error video (CEV) would be as effective as a single visit with a physical therapist (PT) in teaching shoulder exercises when subjects were re-tested one week after initial instruction. Subjects were evaluated using a scoring system (SEAT) that was developed by the author (DBJ) and a physical therapist independent of those used in the study to score subjects. For four shoulder exercises (scapular retraction, standing row, external rotation, internal rotation) there was no difference in exercise performance for subjects taught by a CEV compared to those who had a formal PT visit and were given a take-home handout. Furthermore, subjects at UNC in the CEV group demonstrated strong trends in rating the tool significantly easier to understand and use.

The results of this study build on previous work using instructional videos to teach PT exercises by using a CEV. This format demonstrates not only the correct method of performing an exercise, but also common incorrect methods and mistakes to avoid. These findings concur with previous studies demonstrating that CEV instruction was as effective as one-on-one provider-subject interaction in teaching PT exercises.[1,9,10,11] These results are also in agreement with previous work using various motor tasks (for example, throwing with subject's non-dominant hand) that have demonstrated the utility of corrective feedback in improving performance.[13] Importantly, the current results extend on previous work using a CEV[11] by demonstrating the efficacy of CEV using an independently created video and that information gained from the CEV can be retained by subjects up to one week later. Additionally, the reproducible effect at two separate institutions (UNC and HM), using distinctly different subject populations and DPTs, strengthens the conclusion that CEV is an effective method to communicate shoulder exercise

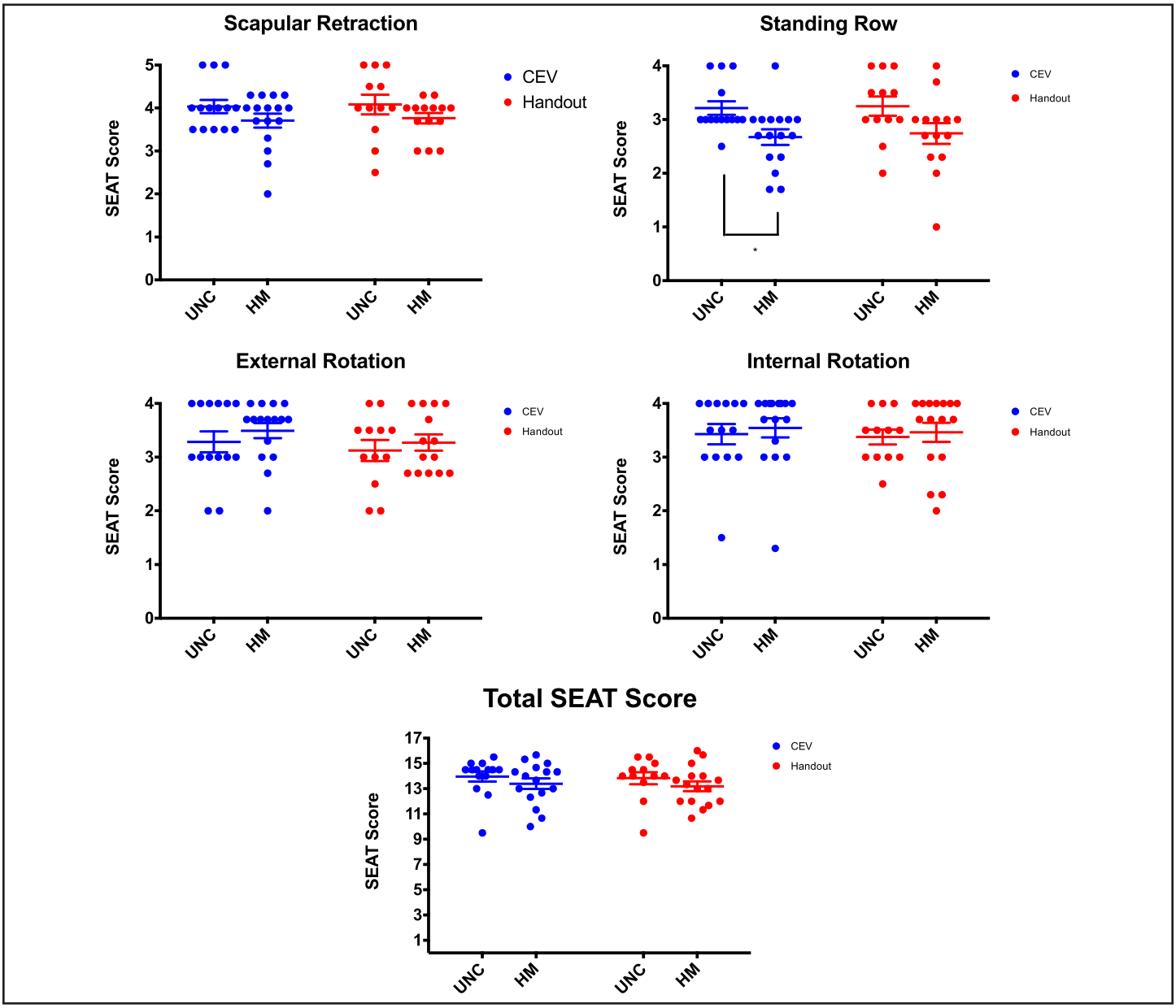

Figure 3. *Performance on Individual Exercises as well as the Total SEAT Score for CEV vs PT Visit group, separated by institution of recruitment.*

instruction when compared to one-on-one therapist interaction, and is therefore a useful alternative method of teaching.

There are limitations to the current study. The SEAT scoring system used to grade subjects has not been thoroughly validated. Future studies will attempt to validate the system. Such a tool will prove useful in objectively evaluating proper execution of PT exercises. Another limitation of this study is our sole focus on shoulder exercises; it is plausible that exercises for other body parts may be harder or easier to teach using the CEV. Nevertheless, these results provide proof-of-principle that the use of a CEV is an effective tool. Subsequent work will extend this investigation to include other body parts (i.e. knee, ankle etc). A final limitation is that the patient population consisted of subjects without shoulder pathology. Future efforts will repeat this study in the injured patient population rather than in recruited subjects, evaluating differences in outcomes from injury (strength, range of motion etc) rather than just instructional efficacy.

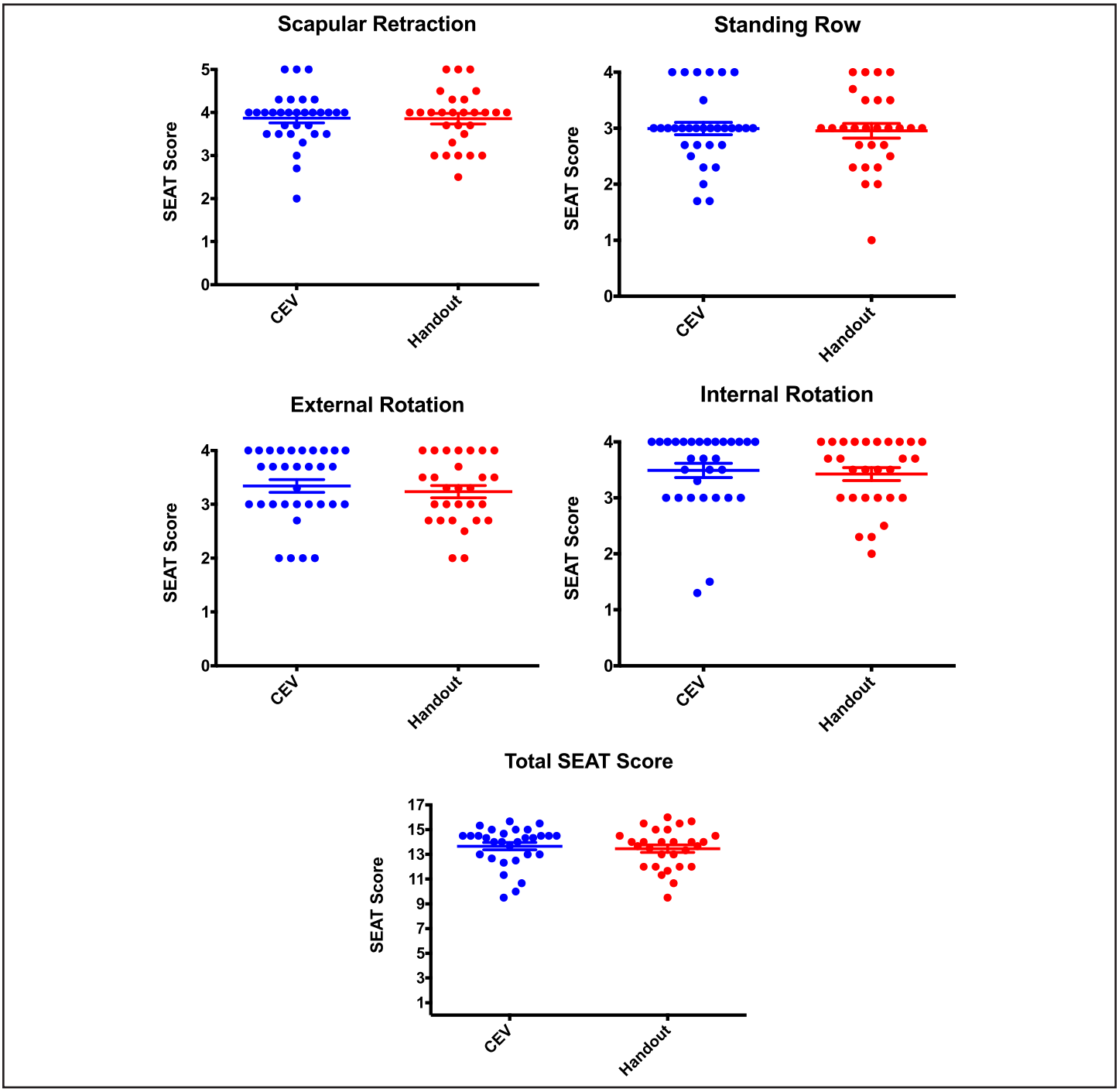

Figure 4. *Performance on Individual Exercises as well as the Total SEAT Score for CEV vs PT Visit group, combining the two institutions.*

CONCLUSIONS

In summary, this study demonstrates that the use of a CEV to teach shoulder exercises results in equivalent performance one week after instruction when compared to the use of in-person instruction. These results show that a CEV is a useful tool to assist physical therapists in communicating information to subjects.

REFERENCES

1. Weeks DL, Anderson LP. The interaction of observational learning with overt practice: Effects on motor skill learning. *Acta Psych*. 2000;104(2):259-71.

2. Novak I. Parent experience of implementing effective home programs. *Phys & Occup Ther Ped.* 2011;31(2):198-213.

3. Opdenacker J, Delecluse C, Boen F. A 2-Year Follow-Up of a Lifestyle Physical Activity Versus a Structured Exercise Intervention in Older Adults. *J Am Geri Soc*. 2011;59(9):1602-11.
4. Mancuso CA, Rincon M. Impact of health literacy on longitudinal asthma outcomes. *J Gen Int Med*. 2006;21(8):813-7.
5. Nutbeam D. Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. *Health Promot Int*. 2000;15(3):259-67.
6. Paasche-Orlow MK, Wolf MS. The causal pathways linking health literacy to health outcomes. *Am J Health Beh*. 2007;31(Supplement 1):S19-26.
7. Friedrich M, Cermak T, Maderbacher P. The effect of brochure use versus therapist teaching on patients performing therapeutic exercise and on changes in impairment status. *Phys Ther.* 1996;76(10):1082-8.
8. Hazard RG, Reid S, Haugh LD, McFarlane G. A controlled trial of an educational pamphlet to prevent disability after occupational low back injury. *Spine.* 2000;25(11):1419-23.
9. Gupta G, Sehgal S. Comparative effectiveness of videotape and handout mode of instructions for teaching exercises: skill retention in normal children. *Ped Rheum*. 2012;10(1):1.
10. Rasmussen L, Justice D, Chang KW, Nelson VS, Yang LJ. Home exercise DVD promotes exercise accuracy by caregivers of children and adolescents with brachial plexus palsy. *P M & R*. 2013;5(11):924-30.
11. Reo JA, Mercer VS. Effects of live, videotaped, or written instruction on learning an upper-extremity exercise program. *Phys Ther*. 2004;84(7):622-33.
12. Adams JA. Historical review and appraisal of research on the learning, retention, and transfer of human motor skills. *Psych Bull*. 1987;101(1):41.
13. Kernodle MW, Carlton LG. Information feedback and the learning of multiple-degree-of-freedom activities. *J Motor Beh*. 1992 ;24(2):187-95.
14. McCullagh P, Caird JK. Correct and learning-models and the use of model knowledge of results in the acquisition and retention of a motor skill. *J Hum Mov Studies*. 1990;18(3):107-16.
15. Newell KM, Shapiro DC. Variability of practice and transfer of training: Some evidence toward a schema view of motor learning. *J Motor Beh.* 1976;8(3):233-43.